Erosion on a Loamy Upland State and Transition Model

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Ecological Site

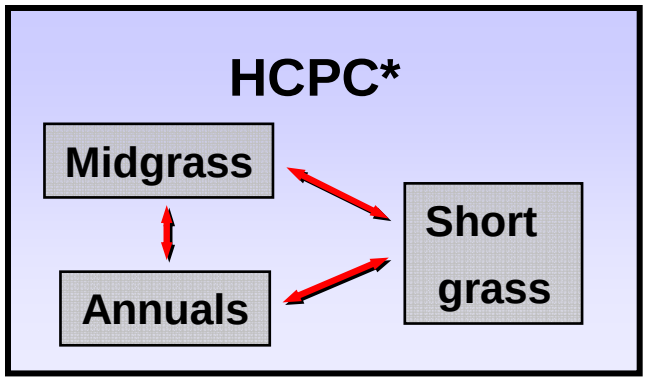
Ecological Site Definition

- "a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation".

Important Characteristics

- soil texture, depth of A horizon, and type of B horizon (clay, calcic)
- position on landscape (slope)

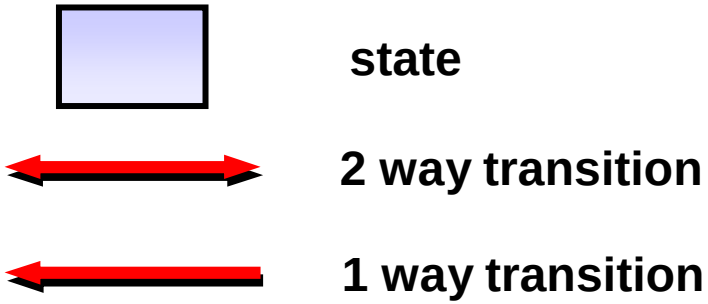
Loamy Uplands (12-16 p.z.) STM



Drought-fire interactions

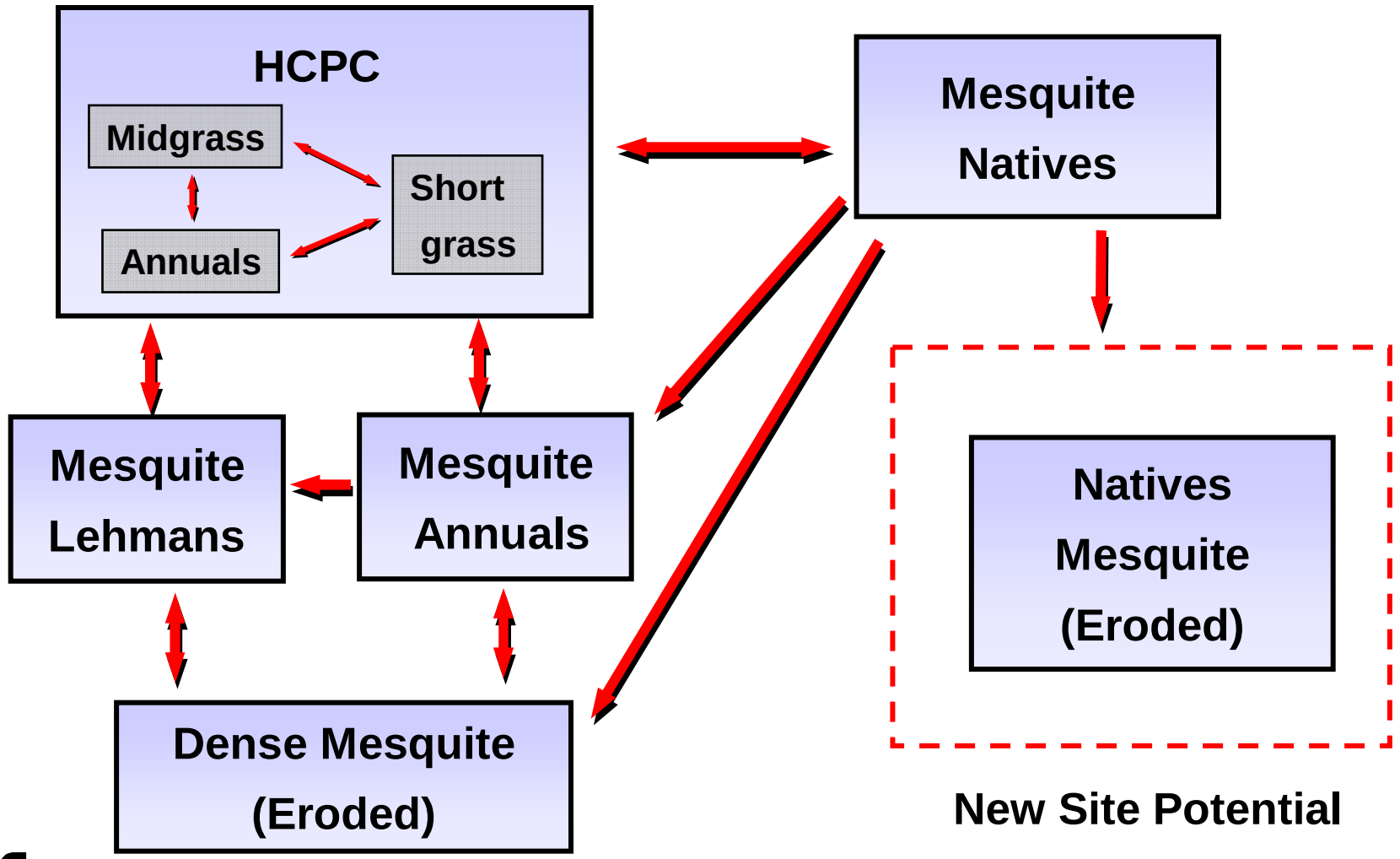
Soil

- gravely sandy loam
- 1- 4 inch A horizon
- clay B horizon



*Historic Climax Plant Community

Loamy Uplands (12-16 p.z.) STM



Erosion on Rangelands

Process	Driver	Modifier
Raindrop detachment	Rainfall energy	Veg/soil characteristics
Transport/Deposition	Runoff Sediment Load Transport Capacity	Slope, roughness, topography
Flow detachment (Sheet, Concentrated flow)		Veg/soil, slope, roughness, topography

Problem Statement

- **STM: States – semi-quantitative,**
  Transitions - qualitative

- **Relationship between STM and erosion is qualitative**

- **Little or no data on dominant erosion process (deposition, transport, flow detachment)**

Rainfall Simulator Experiment

Walnut Gulch Rainfall Simulator

Variable intensity - 25-180 mm/hr

Rainfall Simulator Experiment

4 SMALL PLOTS (0.75 m^2)

rain drop detachment

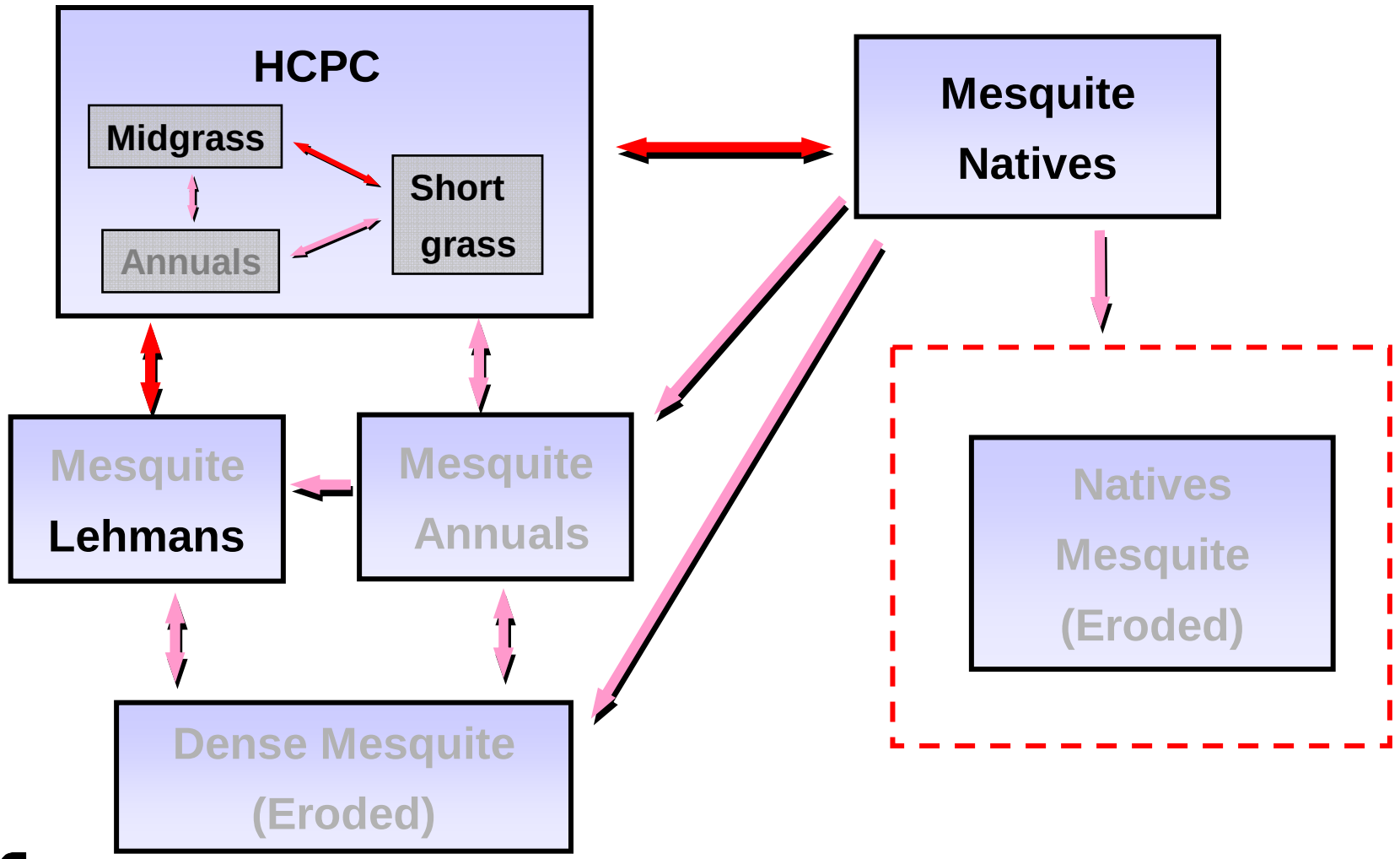
4 LARGE PLOTS (2 x 6 m)

infiltration/runoff

integrated erosion response

rain and flow detachment, transport, deposition

Loamy Uplands (12-16 p.z.) STM



Loamy Uplands States

State	Location	Slope
HCPC - Mid	San Raphael	8
HCPC - Short	Empire	12
Mesquite/Natives High Slope	Empire	14
Mesquite/Natives Low Slope	Empire	4
Lehmans	Walnut Gulch	11

Results – State comparisons

Hydrology and Erosion Characteristics

State	Runoff		Sediment	
	Volume	Peak Rate	Yield	Peak Rate
HCPC - Mid	0.53	0.83	51	2
HCPC - Short	0.80[1]	0.87	217	12
Mes/Nat HS	0.75	0.83	368	21
Mes/Nat LS	0.92	0.93	340	15
Lehmans	0.82	0.86	261	12

[1] blue number means variable is significantly different than the HCPC - Mid ($\alpha = 0.05$)

Rainfall Simulator Experiment

4 SMALL PLOTS (0.75 m^2)

rain drop detachment

4 LARGE PLOTS (2 x 6 m)

infiltration/runoff

integrated erosion response

rain and flow detachment, transport, deposition

Results – Erosion Process

Identifying the Erosion Process

- Use rainfall simulator large and small plot sediment, q_s, and runoff, q, discharge data
- Rain drop detachment is the same on small and large plots
- Any difference between small and large plot sediment discharge, q_s, is assumed to be due to dominant erosion process on the large plot

Results – Erosion Process

Sediment Discharge Comparisons

- small plot q_s > large plot q_s
  - net **deposition** on large plot
- small plot q_s < large plot q_s
  - net flow **detachment** on large plot
- small plot q_s = large plot q_s
  - threshold of deposition/flow detachment on large plot (i.e. net **transport**)

Results – Erosion Process

Sediment Discharge Comparisons

small plot: $\ln(q_s) = \beta_{0S} + \beta_{1S} \ln(q\, S_0)$

large plot: $\ln(q_s) = \beta_{0L} + \beta_{1L} \ln(q\, S_0)$

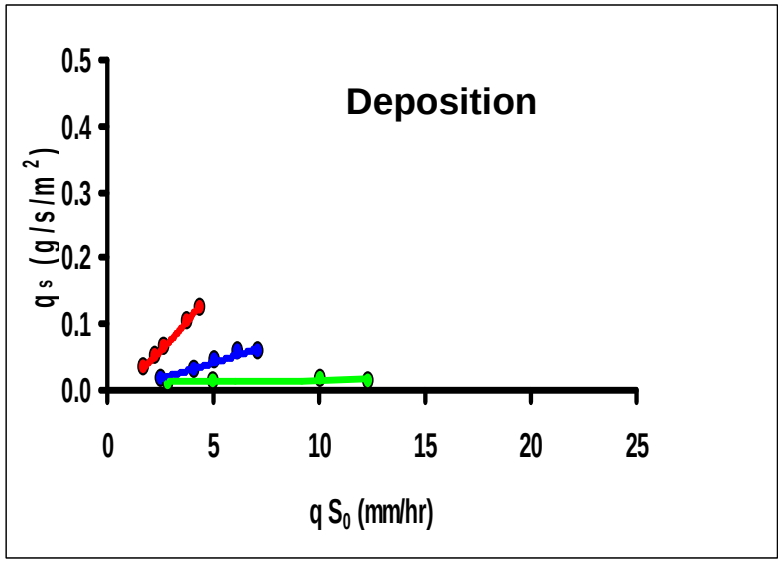
If $\beta_S = \beta_L$ net transport

If $\beta_S > \beta_L$ net deposition

If $\beta_S < \beta_L$ net flow detachment

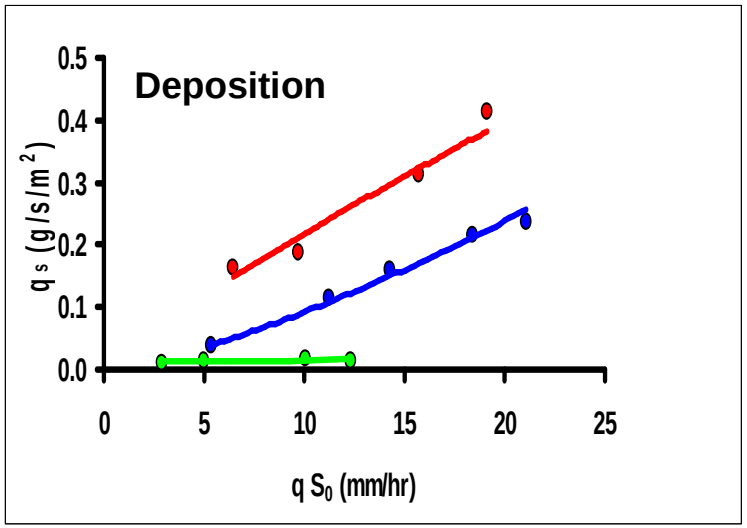
Results – Mesquite Natives LS

small plot
large plot
HCPC - Mid



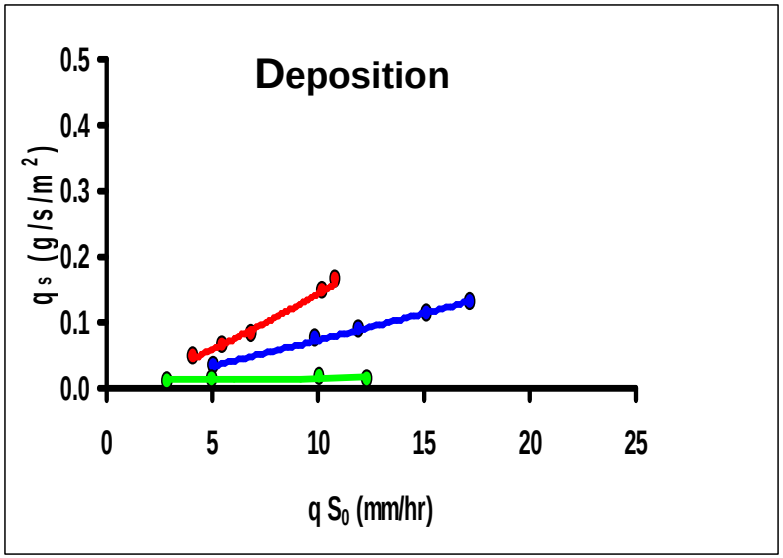
Results – Mesquite Natives HS

small plot
large plot
HCPC - Mid



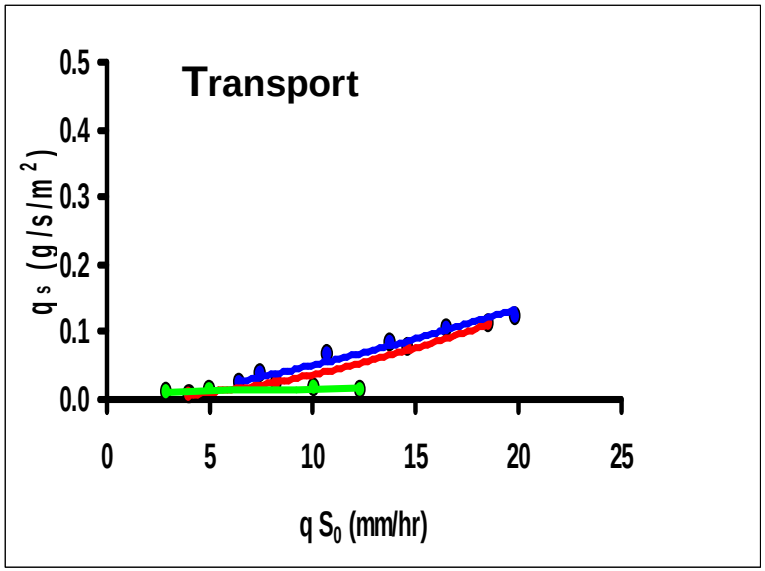
Results – Lehmans

small plot
large plot
HCPC - Mid



Results – HCPC Short Grass

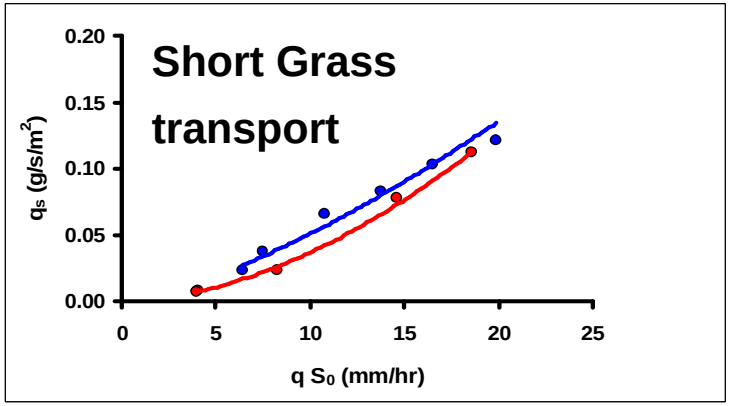
small plot
large plot
HCPC - Mid

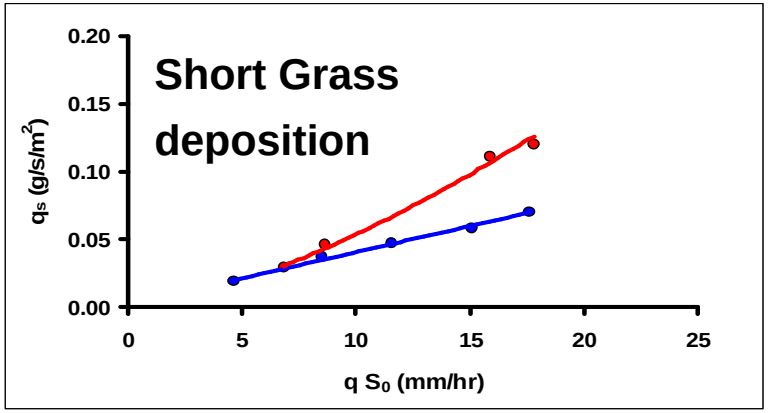


Results – Reduced Grazing

small plot

large plot





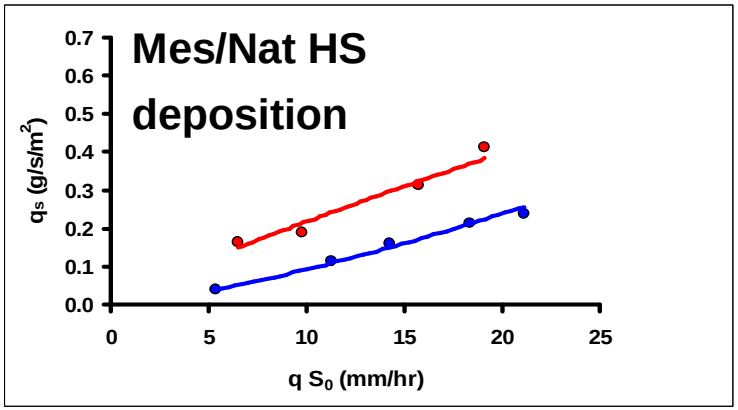
Year 2003 after wildfire, drought, and heavy grazing

Year 2007 reduced grazing

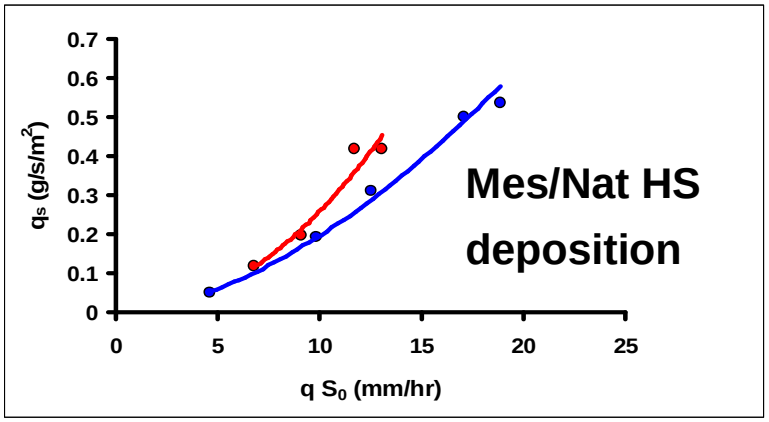
Results – Wildfire

small plot

large plot



wildfire

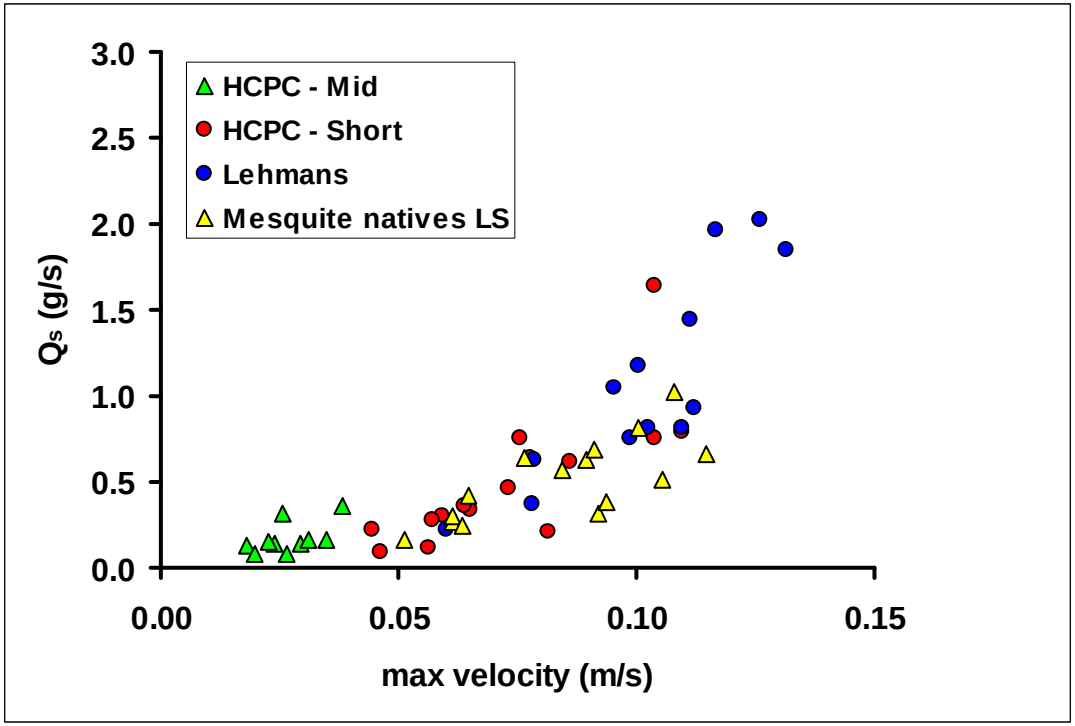


unburned

burned

Results – Main Driver

Sediment discharge as a function of flow velocity



Erosion, Ecological Sites, and STMs

1. HCPC → Degraded states
    a. increased erosion
    b. net deposition

2. Disturbance/Transition:
    a. Net Deposition ↔ Net Transport
    b. Unknown: Net Detachment ↔ Net Transport

3. Main driver is flow velocity which is a function of slope and ground cover, primarily litter cover

Results – State comparisons

Cover Characteristics (%)

State	Litter	Basal	GC	Grass	CC
HCPC - Mid	46	16	72	77	79
HCPC - Short	19[1]	5	51	35	42
Mes/Nat HS	14	5	58	22	26
Mes/Nat LS	21	4	36	24	36
Lehmans	41	4	68	30	49

[1] blue number means variable is significantly different than the HCPC - Mid ($\alpha = 0.05$)

Erosion on Rangelands

Accelerated Erosion

- Erosion rate > soil formation rate
- Sheet or concentrated flow erosion
- Impact on Loamy Upland – loss of A horizon → less water holding capacity → competitive advantage to woody species

Erosion on Rangelands

Basic Concept

- **Raindrop detachment**

  (canopy/ground cover, soil)
- **Flow detachment - sheet or concentrated flow**

  (ground cover, soil, slope, roughness, microtopography)
- **Net transport or Net deposition**

  (slope, roughness, microtopography)

Loamy Uplands Practices

State	Practice
Reference	wildfire
Mesquite/Natives High Slope	wildfire
Mesquite/Natives Low Slope	brush treatment
Short Grass	Drought/Fire/Grazing recovery
Lehmans	natives - Lehmans